The Effects of a Tier 2 Intervention on the Early Numeracy Performance of First Grade Students with Mathematics Difficulties

ANCOVA & RDD: What We're Learning

PCRC
February 2009

Brian R. Bryant, Diane P. Bryant
Greg Roberts, Sharon Vaughn

Andrea Arthur, Sarojani S. Mohammed, Sun A Kim

The University of Texas at Austin: Mathematics
Institute for Learning Disabilities & Difficulties

The Meadows Center
FOR PREVENTING EDUCATIONAL RISK

THE UNIVERSITY OF TEXAS AT AUSTIN
COLLEGE OF EDUCATION

Acknowledgements

- **Intervention Coordinators:**

Kathleen Hughes
Jennifer Porterfield
Tutors

- **Curriculum Development Team:**

Catherine Funk
Kathleen Hughes
Cathy Pool
Jennifer Porterfield
Barbara Scholer-Bryant
Melanie White
Amanda Winter

- **External Reviewers:**

Math specialists

- **Consultants:**

Russell Gersten
Rick Wagner

- **Institute of Education Sciences/ U.S. Department of Education Grant #R324B070164 Goal 2 4 years**

Validating a Response to Intervention Multi-tiered Model for Primary Grades Students with Mathematics Difficulties

Year 1: 1st grade Tier 2 (cohort 1)* 07-08

Year 2: 1st grade Tier 2 (cohort 2) 08-09
2nd grade Tier 2 & Tier 3 (cohort 1)

Year 3: 2nd grade Tier 2 & Tier 3 09-10
(cohort 2)

Year 4: Follow-up testing 2010-11

Rationale

* Preventing learning problems through the identification of students who demonstrate mathematics difficulties and providing evidence-based intervention at an early age is critically important in contributing to academic success (Gersten, Jordan, & Flojo, 2005).

* Ability to understand number, operation, and quantitative reasoning concepts and skills is arguably one of the most important areas of early numeracy (Clements & Sarama, 2004).

* Core number sense developed informally prior to starting school (e.g., numerical values of small quantities, basic counting skills, approximation of the magnitudes of small numbers of objects) (NMAP, 2008, p. 27).

* More advanced number sense developed through formal instruction (e.g., understanding of place value, of how whole numbers, meaning of the basic arithmetic operations) (NMAP, 2008, p. 27)

Purpose

•To provide a description of the Tier 2 mathematics intervention, which was implemented with 203 first grade students who were randomly assigned to a treatment or comparison group, and the results of Year 1.

•To report on the effectiveness of the intervention using the regression discontinuity model (N = 589) as a possible viable design for future research in school settings.

Research Questions

1. What are the effects of Tier 2 intervention on the number, operation, and quantitative reasoning performance of students in first grade who were identified as having mathematics difficulties?

2. Are students who are receiving Tier 2 math intervention (treatment) showing greater gains in mathematics performance than those students who are not receiving the intervention (comparison)?

Design

•Two group pre-post design; random assignment of students to treatment or comparison

Measures

Texas Early Mathematics Inventories-Progress Monitoring (TEMI-PM) [Developed & validated 2004 - 2007]

•Three forms (A, B, C)

•Four subtests: Magnitude Comparisons, Number Sequences, Place Value, and Addition/Subtraction Combinations (group administered; 2-minutes each)

•An aggregate total score (TOT) of the four subtests was used to measure fall, winter, and spring student performance because it is the most robust indicator of performance of the four constructs.

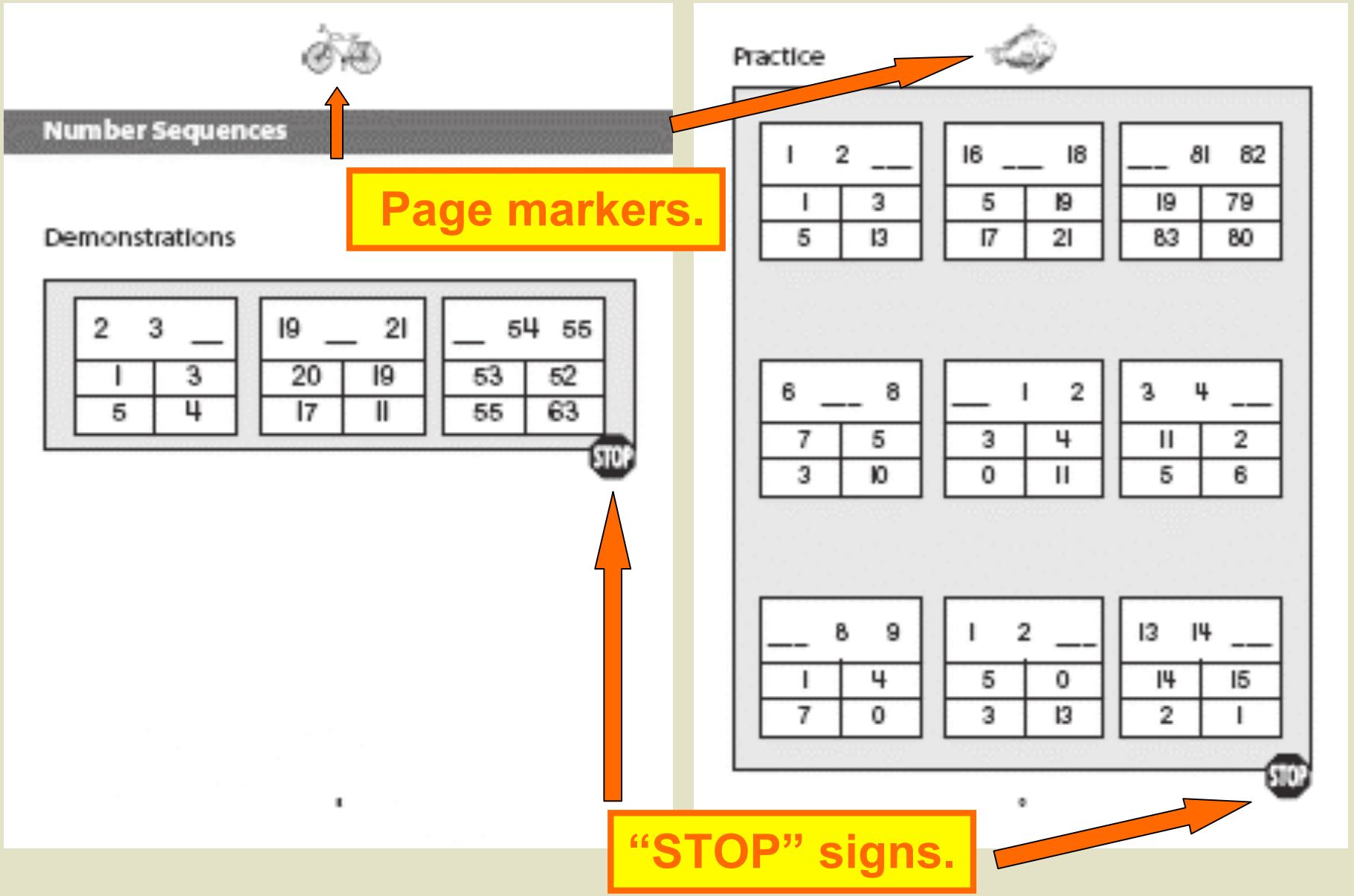
•Test-retest with alternate forms reliability coefficients for the forms ranged from .78 to .86 (median = .80)

SAT-10

•Primary I (Mathematics Procedures [MP] and Mathematics Problem Solving [MPS]), Total Mathematics Score (TMS)

•Concurrent validity of spring Form A TEMI-PM TOT with the Total Mathematics score of the SAT-10 was .72

Using Grade 1 Number Sequences as an example…



Intervention

Tutors

- 5 tutors with degrees in education (general education and/or special education certification) and teaching experience M = 3.4 years (Range = 0 - 7 years; 0 [student teaching])

Training: Initial

- Half day
- Instruction on intervention lessons
- Review of explicit, systematic instruction
- Review of behavior management techniques "Math Ready"
- Practice

Training: Monthly

- Instruction on new units

Fidelity of Implementation

- Degree to which tutors

(a) followed the scripted lessons for the content (e.g., modeling, guided practice, independent practice

(b) implemented the features of explicit, systematic instruction (e.g., pacing, error correction, minimal teacher talks, engagement)

(c) managed student behavior (e.g., use of reinforcers and redirection)

(d) managed the lesson (e.g., use of timer, smooth transitions between booster lessons).

- 0 - 3 point scale where 0 = Not At All, 1 = Rarely, 2 = Some of the Time, 3 = Most of the Time
- 14 observations across 2 observers - Average ratings exceeded 2.5 in all areas, with no single ratings <2.0. Majority of ratings were 3.0

Intervention

Instructional Content (Examples)

Number Knowledge and Relationships

- Count: Rote, Counting Up/Back, Skip (2, 5, 10)
- Read & write numbers: 0 – 99
- Compare & order numbers and magnitude of numbers

Relationships of 10

- Use models to represent numbers: groups of tens and ones
- Create equivalent representations of numbers
- Compose and decompose numbers - multi-digit numbers

Addition & Subtraction Combinations

- Identify and apply properties
- Develop and apply strategies to solve facts (e.g., count on/back doubles, doubles +1, make 10 + more
- Solve addition & related subtraction problems

Intervention

Units/Lessons
- 10 units, 8 lessons per unit
- Daily components: warm-up (review-facts, writing numbers), 2 lessons, cool down

Instructional Routine
- Modeling/modeled practice, guided practice, independent practice, multiple opportunities to respond; error correction; pacing; timer

Grouping
- Homogeneous grouping with 4 - 5 students per group

Duration/Length
- 21 weeks; 4 days per week; 30 min.

Representations
- Physical (concrete), visual (pictorial), abstract (numbers and symbols)

Materials
- 100s chart, 5- and 10-frames, counters, number lines, base-ten materials, fact cards

Progress Monitoring
- Daily checks (lessons for the day)
- Unit checks (multi skills from the unit)
- Aim Checks (fluency)

Intervention (Example)

Strategy Time

Objective:	**The student will be able to use the Make 10 + More strategy to solve addition facts.**
Vocabulary:	**Add, equals, plus, strategy, turnaround fact**
Instructional Content:	**Addition facts to 17 (make 10 + more)**
Materials:	**• Teacher Master pp. • Ten frames & chips (T & S)**

Warm Up: Facts

Look and Say: Hold up fact cards. Students quickly say the answer. Put missed facts in a pile. Use error correction procedures.

Review

Today we will learn a strategy to add numbers up 17. It is the Make 10+ More strategy.

Review: 7 + _ = 10, 8 + _ = 10, 9 + _ = 10. Review: 10 + 1 more = _, 10 + 3 more = _, 10 + 2 more = _, 10 + 9 more = _, 10 + 7 more = _, 10 + 6 more = _, 10 + 5 more = _, 10 + 4 more = _, 10 + 8 more = _.

Intervention (Example)

Modeled Practice (My Turn - Your Turn)

1. **Place the Modeled Practice Sheet on the table. Have students look at their Modeled Practice Sheets. Introduce the make 10 + more strategy using the fact: 9 + 4.**

   There are 3 steps to remember.

   Step 1: Check the fact; is there a 7, 8, or 9 in it? (yes)

   There is a 9 in this fact.

   Step 2: Make 10.

   9 plus what equals 10? (1)

   My turn, I take one chip from the group of four to put with the group of nine. (Move the counter over dotted circle to follow dotted arrow to empty box in top ten frame.)

   I know that 9 + 1 = 10. I made 10!

   Your turn, make 10.

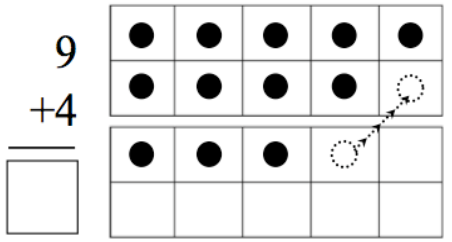
   Step 3: Add 10 + more.

   I have 10 in one frame, plus 3 remaining chips.

   What is 10 + 3? (13)

   So 9 + 4 = 13.

Unit 9
Booster Lesson 1
ASC Day 1
Modeled Practice
Strategy Time
Student



Meadows Center for Preventing Educational Risk:
Mathematics Institute for Learning Disabilities and Difficulties: The University of Texas at Austin
©2009 University of Texas System/Texas Education Agency

Identification

- 777 first graders from 10 elementary schools (central Texas)
- Initial assessment (September, 2007): 269 students scored below the cut score (below the 35th percentile) on the mathematics screening measure (local norms)
- 31 students omitted because of disabilities or ELL status
- Additional assessments (October): remaining 238 students were tested four times using alternate forms of the test
- Application of the "best fit" cut-score identified 224 (94%) students as being at risk for mathematics difficulties, of which 2/3 (n = 150) were assigned to the treatment group and 1/3 (n = 74) to the comparison group. Remainder assigned to Tier 1 group.

Attrition

- One school dropped out; other students moved away.

- At the end of the academic year:
  - Treatment: 139
  - Comparison: 64
  - Tier 1: 450

Participant Demographics

Free & reduced lunch	**(school district)**	**39%**
Ethnicity	**African American** **Hispanic** **White** **Asian/Pacific Islander**	**28.6%** **33.0%** **31.1%** **7.3%**
Gender	**Male 49.7%**	**Female 50.3%**

Research Questions

ANCOVA Study - Experimental design answers the research question: Are students receiving Tier 2 math intervention (treatment) showing greater gains in performance than those students not receiving the intervention (controls)?

RDD Study - Quasi-experimental design answers the research question: What are the effects of Tier 2 intervention on the number, operation, and quantitative reasoning performance of students in first grade who were identified as having mathematics difficulties?

One Study We Found…

"A drug utilization review study was conducted to evaluate a letter intervention to physicians treating Medicaid children with potentially excessive use of short-acting b2-agonist inhalers (SAB). The outcome measure is change in seasonally-adjusted SAB use 5 months pre- and postintervention. To determine if the intervention reduced monthly SAB utilization, results from an RD analysis are compared to findings from a [one group] pretest–posttest design using repeated-measure ANOVA."

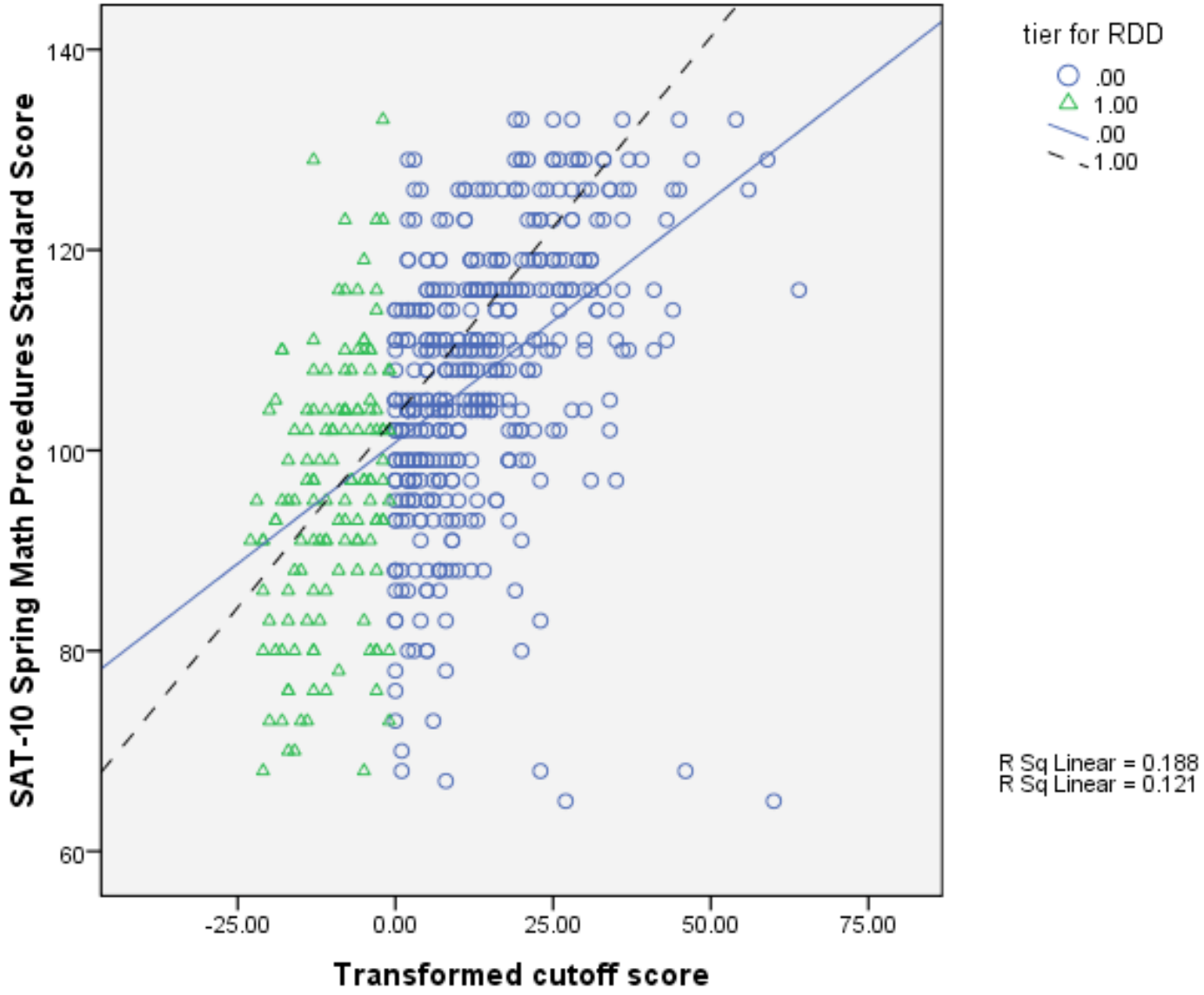
Application of Regression-Discontinuity Analysis in Pharmaceutical Health Services Research I. H. Zuckerman, E. Lee, A. K. Wutoh, Z. Xue, and B. Stuarts

RD Steps

- Note that there are limited supplemental handouts available to those who want to know more about what we have learned in our RD odyssey.

- We provide a step-by-step guide to identify the proper functional form (eliminate misspecification.

Step 1: Plot the Regression



Step 2: Regress Using GLM

Parameter Estimates

Dependent Variable:SAT-10 Spring Math Procedures Standard Score

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	97.772	1.094	89.402	.000	95.624	99.920	.932
tierrdd	2.596	3.274	.793	.428	-3.834	9.027	.001
precul	1.003	.125	8.032	.000	.758	1.248	.100
interact	-1.041	.688	-1.514	.131	-2.393	.310	.004
quad	-.012	.003	-4.487	.000	-.018	-.007	.033
quadinteract	-.024	.030	-.801	.423	-.084	.035	.001

Step 2 (cont.): Eliminate Quad x Interaction

Parameter Estimates

Dependent Variable:SAT-10 Spring Math Procedures Standard Score

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	97.723	1.092	89.527	.000	95.579	99.866	.932
tierrdd	4.571	2.155	2.121	.034	.338	8.803	.008
precul	1.011	.124	8.131	.000	.767	1.256	.102
interact	-.527	.246	-2.139	.033	-1.010	-.043	.008
quad	-.013	.003	-4.581	.000	-.018	-.007	.035

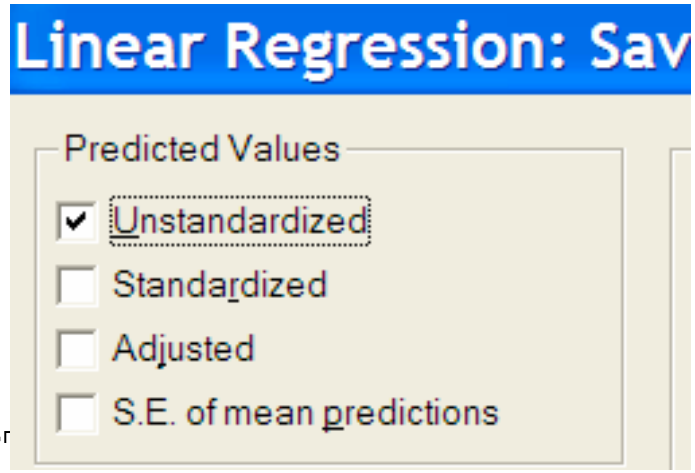
Step 3: Run Linear Regression

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	RDD quadratic term, RDD treatment by score interaction, tier for RDD, Transformed cutoff score[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: SAT-10 Spring Math Procedures Standard Scor

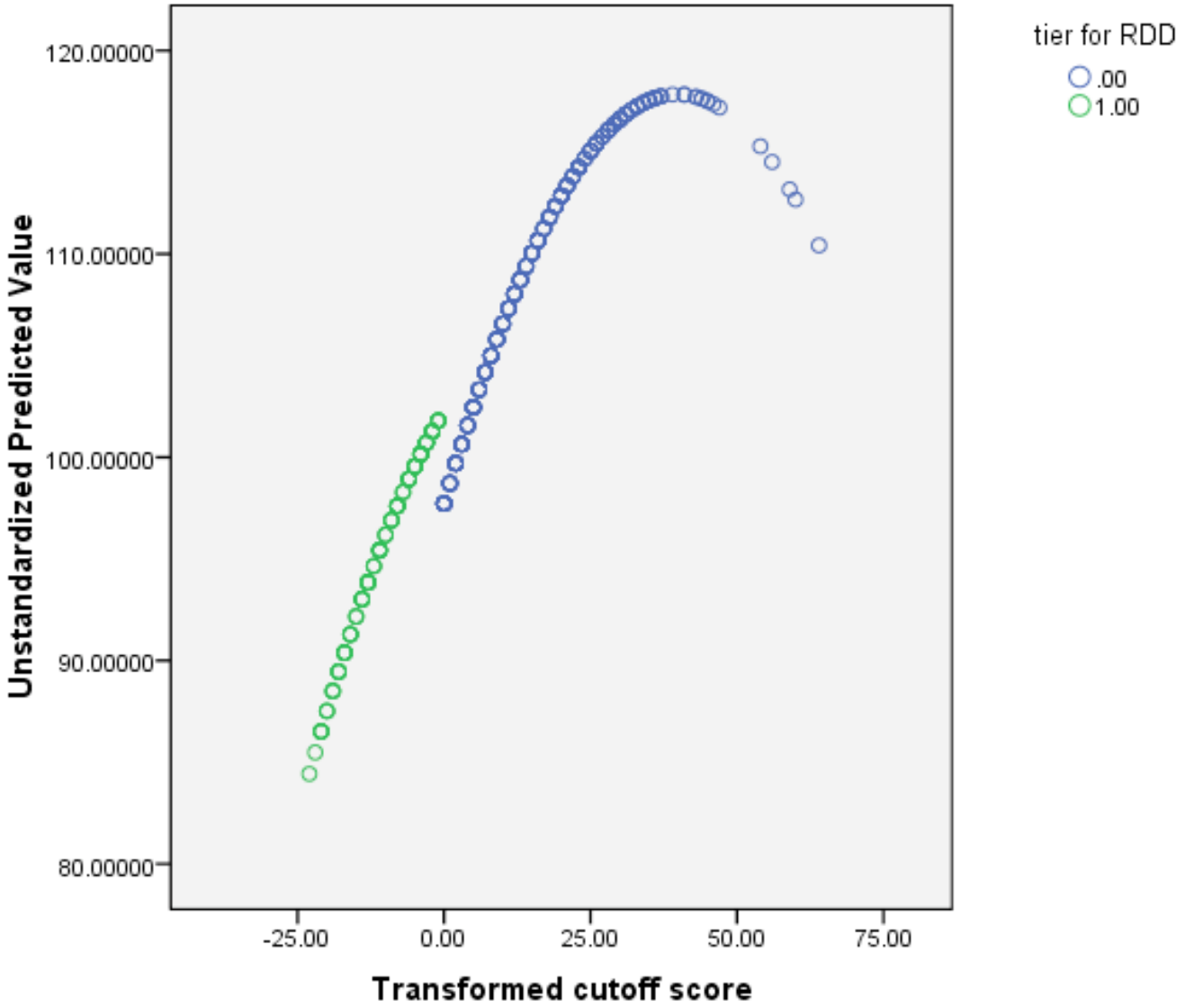


Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	97.723	1.092		89.527	.000
	tier for RDD	4.571	2.155	.138	2.121	.034
	Transformed cutoff score	1.011	.124	1.055	8.131	.000
	RDD treatment by score interaction	-.527	.246	-.191	-2.139	.033
	RDD quadratic term	-.013	.003	-.428	-4.581	.000

a. Dependent Variable: SAT-10 Spring Math Procedures Standard Score

Step 4: Re-run Scatterplot



Comparisons Between ANCOVA and Regression Discontinuity Analyses

ANCOVA						Regression Discontinuity					
Measure	Comparison (N=64)	Treatment (N=139)	F	Sig.	Partial eta^2 ($\acute{\eta}_p^2$)	Parameter	Unst. Coef. B	t	sig	Partial eta^2 ($\acute{\eta}_p^2$)	Agmt.
SAT-10 Total	89.39	91.82	2.19	.14	.01	(Constant) Precut Group LinInter Quad	96.3 1.05 2.71 -.491 -.013	104.8 10.0 1.49 -2.37 -5.70	.000 .000 .136 .018 .000	.949 .146 .004 .010 .053	Yes
SAT-10 Procedures	92.19	95.87	3.65	.05	.02	(Constant) Precut Group LinInter Quad	97.72 1.01 4.57 -.527 -.013	89.53 8.13 2.12 -2.14 -4.58	.000 .000 .034 .033 .000	.932 .102 .008 .008 .035	Yes
SAT-10 Problem Solving	88.27	89.83	1.01	.32	.005	(Constant) Precut Group Quad	96.86 .790 1.95 -.010	136.2 11.88 1.215 -6.30	.000 .000 .225 .000	.969 .194 .003 .063	Yes
TEMI-O Total Score	43.35	46.10	3.82	.05	.02	(Constant) Precut Group Quad	48.80 .564 3.55 -.007	92.16 11.39 2.972 -5.96	.000 .000 .003 .000	.936 .182 .015 .057	Yes
TEMI-O Problem Solving	26.89	26.89	0.00	.99	.00	(Constant) Precut Group Quad	29.53 .253 .280 -.004	99.22 9.10 .418 -5.93	.000 .000 .676 .000	.944 .124 .000 .057	Yes
TEMI-O Computation Outcome	16.46	19.15	12.11	<.01	.06	(Constant) Precut Group Quad	19.26 .311 3.27 -.003	57.94 9.99 4.36 -4.18	.000 .000 .000 .000	.852 .146 .032 .029	Yes

Comparisons Between ANCOVA and Regression Discontinuity Analyses (continued)

ANCOVA						Regression Discontinuity					
Measure	Comparison (N=64)	Treatment (N=139)	F	Sig.	Partial eta^2 ($\acute{\eta}_p^2$)	Parameter	Unst. Coef. B	t	sig	Partial eta^2 ($\acute{\eta}_p^2$)	Agmt.
TEMI-PM Total Score	78.00	89.1	14.94	<.01	.07	(Constant) Precut Group	96.03 1.25 5.06	67.90 16.23 1.908	.000 .000 .057	.887 .313 .006	No
TEMI-PM Magnitude Comparisons	32.99	34.62	2.02	.16	.01	(Constant) Precut Group	39.67 .405 -1.13	69.98 13.19 -1.06	.000 .000 .290	.893 .229 .002	Yes
TEMI-PM Number Sequences	15.70	18.98	13.78	<.01	.06	(Constant) Precut Group	20.11 .308 1.81	45.65 12.9 2.20	.000 .000 .029	.781 .221 .008	Yes
TEMI-PM Place Value	15.62	17.88	9.72	<.01	.05	(Constant) Precut Group	18.39 .179 1.172	53.99 9.69 1.84	.000 .000 .067	.833 .138 .006	No
TEMI-PM Addition Subtraction	13.68	17.58	16.34	<.01	.08	(Constant) Precut Group	17.86 .359 3.196	38.9 14.44 3.716	.000 .000 .000	.721 .262 .023	Yes

For RD Analysis: Treatment = 139, Comparison = 450 (N=589)

What have we learned?

- Group testing can be efficient.
- Teachers know their kids.
- Lessons are reasonably effective in teaching students NOQR skills, when tutors are used; what about teachers?
- Impact is largest on aligned measures (Lonigan)
- More instructional time is needed.
- Teachers want to see improvement on all TEKS

What have we learned? (cont.)

- "What do I do with the rest of the class?" – Tier 2 instruction can not be at the expense of core.
- Fidelity is critical – All tutors are NOT created equal!
- Decision rules need to be created for when students are not making progress.
- Teachers can conduct group assessments that have reliability and yield valid results.
- RD seems to be as effective as ANCOVA in finding treatment results.
- RtI is a lot of work!